ECOLOGICAL STUDIES OF MEDUSA AURELIA AURITA LAMARCK-II. DISTRIBUTION AND BIOMASS OF AURELIA IN LAKE HAMANA IN SUMMER 1965.

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ECOLOGICAL STUDIES OF MEDUSA *AURELIA AURITA* LAMARCK-II. DISTRIBUTION AND BIOMASS OF *AURELIA* IN LAKE HAMANA IN SUMMER 1965.[1)]

By

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Thermal power station and other littoral factories using sea water for condenser cooling face frequently to the plugging of the condenser system by *Aurelia* patches. As for the planning of countermeasures, it is necessary to accumulate knowledges on the distribution of *Aurelia*, of which the reports are very few. Earlier in our work (OSHIMA et al., 1967) dealing with the experiments on the accomodation of density in *Aurelia*, it was suggested that its vertical distribution might be restricted by the density of the environments. Materials used in the work were collected from a brackish lake Hamana and their distribution was also investigated simultaneously. The object of this paper is to present the summary of the investigation and to support the above-mentioned suggestion by the result of field work, as well as to contribute to the estimation of biomass of *Aurelia*.

DESCRIPTION OF STUDY AREA AND METHODS

Lake Hamana lies in middle Pacific coast of Main Island "Honshu" in the position at 34°40–50'N and 137°30–40'E, covering an area of 73.5 km^2. It has many small bays and rivers which make the shoreline indented as shown in Fig. 1. The main lake has a flat basin in its northern part with the depths of about 9–12 m and the maximum of 15.8 m. Its south end connected with the open sea by IMAKIRI straits. Therefore, hydrographic conditions are considerably different between the northern and the southern parts.

The investigation was carried out on July 9 to 12, 1965 at 22 stations which were established dispersively so that they can cover whole area of the lake as in Fig. 1. A special net for medusae collections, its filtering part being made of nylon net-cloth with 8 mm mesh apertures, and the mouth opening being 1 m in diameter,

1) Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 365

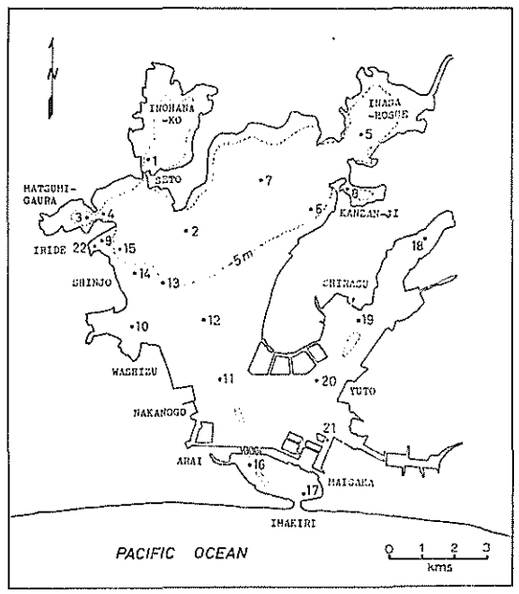

Fig. 1. Lake Hamana showing the 5-metre contour lines and the locations of sampling stations (1-22).

was hauled vertically in each designed layers in a station. Occurrence of medusae in each layer was calculated from the difference of catches of the deeper and the shallower hauls. Water samples were taken for the analyses of density *in situ* by Akanuma's hydrometer and of dissolved oxygen by Winkler's method. Plankton samples were collected by vertical hauling of a 22.5 cm open net (XX 13, 0.095 mm mesh apertures).

RESULTS AND DISCUSSION

The organism obtained by the hauling of the special medusae net was *Aurelia aurita* alone. It was caught at 12 stations of all the established stations. The mean density of *Aurelia* at each station was illustrated on Fig. 2. It is clearly shown that *Aurelia* were distributed mostly in the area which depth is more than 5m except Station 21. This area is the part of central flat basin. High occurrence of *Aurelia* rather was found at the stations located in the entrance of annexed bays. The highest occurrence, 24.7 individuals per 1 cubic meter, was seen at Station 9 at IRIDE; Station 1 at the entrance of INOHANAKO ranks next.

All the results of the investigation in each station where *Aurelia* occurred were shown in Table 1, in which the vertical distribution of *Aurelia* can be examined with the analysed hydrographic conditions of the environment. *Aurelia* was generally found in the middle and the bottom layers of each station, the highest occurrence

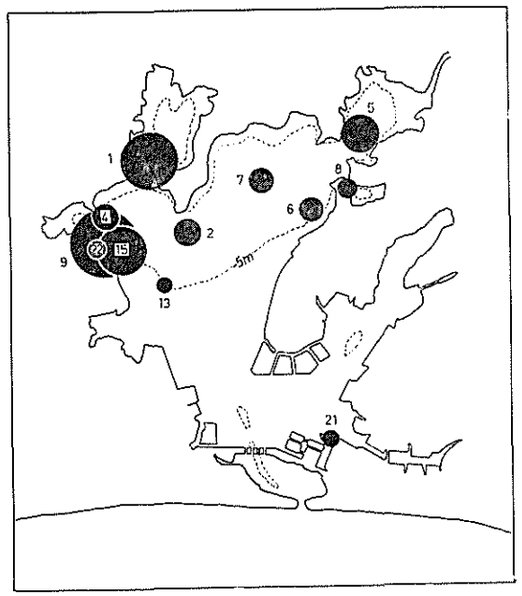

Fig. 2. Occurrence of *Aurelia aurita* at each station in Lake Hamana. The radii of the circles are obtained by $r\,(\mathrm{mm}) = \sqrt[3]{\frac{\mathrm{Nos./m^3}}{4}} \times 4.1$ according to LOHMANN's method.

being considered at a depth of 4–6 m. The maximum occurrence, 103.1 individuals per 1 m^3, was found in a layer between 4 and 5 m of Station 9; the minimum, 0.3 individuals per 1 m^3 in a layer shallower than 4 m of Station 6. The pattern of hydrographic conditions where *Aurelia* were found was similar in every stations with a few of exceptions. Namely, density of water *in situ* was appeared to be the lowest at the surface and increased with depth. Water temperature and amount of dissolved oxygen generally decreased with depth. Effect of a heavy rain and inflow was observed by the fall of water temperature at the surface of Station 1, 2, 4, and 5. Thermocline was not remarkable in every stations. Feature of stagnation can be seen from these descriptions and Table 1 with the wide ranges of water qualities; 5.5–20.4 of density *in situ*, 20.0–26.2°C of water temperature, and 0–7.25 ml/l of dissolved oxygen.

The vertical distribution of *Aurelia*, which is supposed to have its own specific density of body, in middle layer may be attributed to the sinking from the upper layer of low density *in situ* and to the rising up from the lower layer of high density *in situ*. The laboratorial experiment carried out at the same time showed that *Aurelia* having its density of 15.7 suspended in the artificial interface between layers of density *in situ* 8.2 and 19.7, which was similar to the condition of Station

Table 1. Occurrence of *Aurelia aurita* and analytical data of hydrographic conditions in stations where *Aurelia* occurred in Lake Hamana on July 9-12, 1965.

Station	Temperature (°C)	σ_t *	Dissolved Oxygen (ml/l)	Depth (m)	Occurrence of *Aurelia*		Settling Volume of Plankton (ml/m³)
					Density (Nos./m³)	Biomass (g/m³)	
1	22.3	—	—	0	0	0	—
	24.7	7.5	4.60	3.0			
	23.6	—	—	4.0			
	23.4	14.8	1.45	4.5	54.8	432.9	
	23.2	—	—	5.0			
	20.0	20.4	0.00	8.0B**	19.9	157.2	
2	23.7	8.7	—	0	0	0	3.32
	23.2	15.4	2.99	4.0	6.4	50.6	0.00
	22.8	17.1	1.78	6.0			
	20.5	20.3	0.00	10.0	0	0	
4	23.7	—	—	0	1.0	6.1	3.32
	23.3	14.8	1.59	3.5			
	23.2	—	—	4.0	7.0	42.7	0
	22.4	17.0	—	5.0			
	21.8	17.6	0.41	6.0			
	21.0	—	—	8.0	0	0	
5	21.4	—	—	0	0	0	2.95
	24.0	5.5	7.25	1.0	8.9	106.8	
	23.9	—	—	2.0	6.4	28.8	0
	23.5	14.4	2.74	3.0	8.9	70.3	
	23.2	15.0	2.18	4.0			
	22.8	15.1	—	5.0	16.1	114.3	
	22.3	16.5	1.41	6.0			
	22.0	—	—	6.5 B			
6	24.6	—	—	0	0.3	2.4	2.21
	23.1	15.1	2.50	4.0			
	22.5	15.4	2.01	5.0	5.7	34.8	0
	22.4	—	—	6.0			
	21.2	19.4	0.43	8.5	0	0	
	20.4	—	—	9.5 B			
7	24.7	—	—	0	0	0	2.77
	23.4	14.1	3.36	4.0	2.6	15.9	0
	22.3	15.1	1.38	6.0			
	21.2	17.1	—	8.0	1.9	11.6	
	20.7	19.3	0.08	11.0	—	—	
8	26.1	—	—	0	0	0	1.97
	23.7	—	—	3.0	2.6	15.9	
	23.3	—	—	4.0	0.6	3.7	0.74
	23.1	14.2	2.06	4.5			
	22.5	14.3	2.76	6.0			
	20.7	18.7	1.15	8.0	0.9	5.5	
	20.6	—	—	9.0 B			

Table. 1. Continued

Station	Temperature (°C)	σ_t *	Dissolved Oxygen (ml/l)	Depth (m)	Occurrence of *Aurelia*		Settling Volume of plankton (ml/m³)
					Density (Nos./m³)	Biomass (g/m³)	
9	25.0	—	—	0	0	0	6.63
	24.2	9.3	6.81	2.0	22.9	139.7	0
	23.6	13.3	1.00	3.0	66.2	403.8	
	23.2	—	—	4.0	103.1	814.5	
	22.9	14.8	1.26	5.0			
	—	—	—	6.5 B	0	0	
13	—	—	—	0	0.6	3.9	—
	—	—	—	6.0			
15	24.9	—	—	0	0	0	1.77
	24.4	—	—	2.0			
	23.7	13.8	2.41	2.5	10.2	45.9	0.13
	23.7	—	—	3.0			
	23.3	—	—	4.0	24.2	147.6	
	22.9	15.3	—	4.5			
	22.9	15.3	2.61	5.0	24.2	191.2	
	22.2	—	—	6.0			
	21.2	15.8	1.67	7.0	0	0	
	20.7	—	—	7.5 B			
21	26.2	12.6	5.76	0	0.58	3.5	37.61
	25.0	16.0	6.10	2.0			
22	24.4	12.7	3.96	0	0.73	4.5	13.27
	23.4	14.3	1.91	2.5			

* Density *in situ*, $\sigma_t=(\rho_t-1)\times1000$
** Bottom

1 (OSHIMA et al., 1967). Unless the mixing of water occurs with the change of physical hydrographic conditions, such feature of vertical distribution of *Aurelia* will continue, although its specific density accommodated to that of the environment when it was immersed in the water of above-mentioned density in the experiments. The hydrographic condition of the occurrence of *Aurelia* can be summarized with 5.5–18.7 of density *in situ*, 20.8–26.2°C of water temperature and 0.4–7.3 ml/l of dissolved oxygen, which were obtained by means of interpolation in Table 1. And the highest occurrence is seen in the condition of 12.5–16.6 of density *in situ*, 22.5–23.9°C of water temperature except St. 21, and 0.9–3.0 ml/l of dissolved oxygen.

The hydrographic conditions in which *Aurelia* was not collected are shown in Table 2. The majority of these stations was shallower than nearly 3 m. Water temperatures of these stations were 22.0–27.6°C, which were a little higher than that in which *Aurelia* occurred. Densities *in situ* were either higher as at Station 3, 16, and 17, or lower as at Station 11, 18, and 19, than that in which *Aurelia*

Table 2. Hydrographic conditions in stations where *Aurelia* was not collected in Lake Hamana on July 9-12, 1965.

Station	Depth (m)	Temperature (°C)	σ_t	Dissolved Oxygen (ml/l)	Settling Volume of Plankton (ml/m³)
3	0 4.0 6.0	23.4 22.7 22.0	— 15.3 17.6	— 0.90 0.23	2.58
10	3.0	23.4	14.1	5.74	—
11	1.0 2.5	24.5 24.0	3.0 8.2	7.16 6.30	2.53
12	1.0 3.0	24.5 23.1	4.1 16.4	8.44 4.39	5.06
16	0 1.0 3.0	24.2 23.4 23.2	7.2 11.6 16.8	— 5.60 5.53	39.08
17	0 1.0 3.0	23.4 23.0 22.8	19.3 19.7 19.8	— 5.93 5.90	131.26
18	1.0 2.5	27.6 25.0	2.0 6.9	8.30 1.54	6.19
19	1.0 1.8	27.1 25.0	2.0 7.1	9.64 1.97	12.17
20	1.0 4.0	26.4 24.8	6.6 10.1	7.87 5.72	2.95

occurred, if remotely compared. The values of dissolved oxygen were almost higher than 5 ml/l which is not disagreeable condition for general aquates. Dissolved oxygen is therefore not considered as a limitation factor of the distribution of *Aurelia* in the present environment.

Plankton biomass ranged from 0 to 131.26 ml/m³ by settling volume, was generally abundant in surface. Copepods, *Oithona* and *Acartia* were the predominant plankton at every stations except St. 17 and 21 where the diatom, *Chaetoceros decipiens* was predominant. There was a negative relationship between the occurrence of *Aurelia* and settling volume of plankton. In regard to feeding habit of *Aurelia*, reports indicated that its younger stages are carnivorous (LEBOUR, 1922–23, 1925) and adult is plankton feeder (SOUTHWARD, 1955). As the author holds the same view, it is no wonder even if there will be some positive relationship between the occurrence of *Aurelia* and the volume of plankton. But the observed negative relationship will not support directly that the plankton is a limitation factor of the distribution of *Aurelia* from this viewpoint.

From all these considerations, it would be thought that density *in situ* is still remained within the range of possibility to be an important factor limiting the distribution of *Aurelia* in the present environment. This opinion is uniform as that of the author's investigation in Tokyo Bay (KUWABARA et al., in press). Almost all the *Aurelia* in Lake Hamana might be sinking in deeper layer of the central flat basin, while they were not seen in the surface water being low density *in situ* in where with an exception of St. 21.

Biomass calculated from mean diameter of the bell of *Aurelia* and density of its occurrence in each layers using the relationship between wet weight (Y g) and diameter of the bell (X mm), $Y=0.821\ X^{2.632}$, were 814.5 g/m³ in the maximum in the layer between 4 and 5 m of St. 9 and 2.4 g/m³ in the minimum in the layer shallower than 4 m of St. 6. These figures are within the range of values obtained in Tokyo Bay. The size of *Aurelia* was, however, 16–64 mm in diameter of the bell which was much smaller than that in Tokyo Bay, though it was not young form.

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